CLAIMS

1. A magnetic head assembly having an air bearing surface (ABS) comprising:

Sub A1

a read head including:

first and second ferromagnetic shield layers;

a read sensor recessed from the ABS and which includes a ferromagnetic free layer;

a ferromagnetic flux guide magnetically connected to the read sensor and extending from the read sensor to the ABS for conducting field signals to the read sensor;

each of the read sensor and the flux guide being located between ferromagnetic first and second shield layers;

a distance between the first and second shield layers at the ABS being less than a distance between the first and second shield layers at the read sensor; and

a longitudinal biasing stack (LBS) magnetically coupled to the free layer for biasing a magnetic moment of the free layer parallel to the ABS and parallel to major planes of the layers.

2. A magnetic head assembly as claimed in claim 1 wherein the LBS includes:

a hard bias layer; and

a nonmagnetic metal spacer layer located between and interfacing the free layer and the hard bias layer.

3. A magnetic head assembly as claimed in claim 1 wherein the LBS includes:

a ferromagnetic pinned layer;

a nonmagnetic metal spacer layer located between and interfacing the free layer and the pinned layer; and

Sub A1 Con't

an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning a magnetic moment of the pinned layer.

4. A magnetic head assembly as claimed in claim 1 wherein the spacer layer is tantalum (Ta) and the pinned layer is magnetostatically coupled to the free layer.

5. A magnetic head assembly as claimed in claim 1 wherein the spacer layer is ruthenium (Ru) and the pinned layer is antiparallel coupled to the free layer.

6. A magnetic head assembly as claimed in claim 1 wherein the spacer layer is a nonmagnetic electrically nonconductive barrier layer.

7. A magnetic head assembly as claimed in claim 1 further comprising:

the flux guide including an extension of the free layer which extends from the sensor to the ABS;

the read sensor further including:

a ferromagnetic pinned layer that has a magnetic moment;

an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning the magnetic moment of the pinned layer; and

a spacer layer located between the pinned layer and said free layer; and

said pinned layer, pinning layer and spacer layer being located only in said read sensor.

8. A magnetic head assembly as claimed in claim 7 further comprising:

a write head including:

ferromagnetic first and second pole piece layers that have a yoke portion located between a pole tip portion and a back gap portion;

a nonmagnetic write gap layer located between the pole tip portions of the first and second pole piece layers;

Sub A1 Con't

an insulation stack with at least one coil layer embedded therein located between the yoke portions of the first and second pole piece layers; and

the first and second pole piece layers being connected at their back gap portions.

9. A magnetic head assembly as claimed in claim 8 including:

the second shield layer being located between the first shield layer and the second pole piece layer; and

the free layer being located between the pinned layer and the second shield layer.

10. A magnetic head assembly as claimed in claim 8 including:

the second shield layer being located between the first shield layer and the second pole piece layer; and

the pinned layer being located between the free layer and the second shield layer.

11. A magnetic disk drive including:

a read head including:

first and second ferromagnetic shield layers;

a read sensor recessed from the ABS and which includes a ferromagnetic free layer;

a ferromagnetic flux guide magnetically connected to the read sensor and extending from the read sensor to the ABS for conducting field signals to the read sensor;

each of the read sensor and the flux guide being located between ferromagnetic first and second shield layers;

a distance between the first and second shield layers at the ABS being less than a distance between the first and second shield layers at the read sensor; and

Sub A1 Cont

a longitudinal biasing stack (LBS) magnetically coupled to the free layer for biasing a magnetic moment of the free layer parallel to the ABS and parallel to major planes of the layers;

a write head including:

ferromagnetic first and second pole piece layers that have a yoke portion located between a pole tip portion and a back gap portion;

a nonmagnetic write gap layer located between the pole tip portions of the first and second pole piece layers;

an insulation stack with at least one coil layer embedded therein located between the yoke portions of the first and second pole piece layers; and

the first and second pole piece layers being connected at their back gap portions;

a housing;

a magnetic disk rotatably supported in the housing;

a support mounted in the housing for supporting the magnetic head assembly with said ABS facing the magnetic disk so that the magnetic head assembly is in a transducing relationship with the magnetic disk;

a spindle motor for rotating the magnetic disk;

an actuator positioning means connected to the support for moving the magnetic head assembly to multiple positions with respect to said magnetic disk; and a processor connected to the magnetic head assembly, to the spindle motor and to the actuator for exchanging signals with the magnetic head assembly, for controlling movement of the magnetic disk and for controlling the position of the magnetic head assembly.

12. A magnetic disk drive as claimed in claim 11 wherein the LBS includes:

a hard bias layer; and

a nonmagnetic metal spacer layer located between and interfacing the free layer and the hard bias layer.

Sub A17 con't

13. A magnetic disk drive as claimed in claim 11 wherein the LBS includes:

a ferromagnetic pinned layer;

a nonmagnetic metal spacer layer located between and interfacing the free layer and the pinned layer; and

an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning a magnetic moment of the pinned layer.

14. A magnetic disk drive as claimed in claim 11 wherein the spacer layer is tantalum (Ta) and the pinned layer is magnetostatically coupled to the free layer.

15. A magnetic disk drive as claimed in claim 11 wherein the the spacer layer is ruthenium (Ru) and the pinned layer is antiparallel coupled to the free layer.

16. A magnetic disk drive as claimed in claim 11 wherein the spacer layer is a nonmagnetic electrically nonconductive barrier layer.

17. A magnetic disk drive as claimed in claim 11 further comprising:

the flux guide including an extension of the free layer which extends from the sensor to the ABS;

the read sensor further including:

a ferromagnetic pinned layer that has a magnetic moment;

an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning the magnetic moment of the pinned layer; and

a spacer layer located between the pinned layer and said free layer; and

said pinned layer, pinning layer and spacer layer being located only in said read sensor.

Sub A17 cont

18. A magnetic disk drive as claimed in claim 17 including:

the second shield layer being located between the first shield layer and the second pole piece layer; and

the free layer being located between the pinned layer and the second shield layer.

19. A magnetic disk drive as claimed in claim 17 including:

the second shield layer being located between the first shield layer and the second pole piece layer; and

the pinned layer being located between the free layer and the second shield layer.

20. A method of making a magnetic head assembly having an air bearing surface (ABS) comprising the steps of:

forming a read head including the steps of:

forming first and second ferromagnetic shield layers;

forming a read sensor recessed from the ABS with the read sensor including a ferromagnetic free layer;

forming a ferromagnetic flux guide magnetically connected to the read sensor and extending from the read sensor to the ABS for conducting field signals to the read sensor;

forming each of the read sensor and the flux guide between ferromagnetic first and second shield layers with a distance between the first and second shield layers at the ABS being less than a distance between the first and second shield layers at the read sensor;

forming an insulation layer between the free layer and one of the shield layers; and

forming a longitudinal bias stack (LBS) magnetically coupled to the free layer for biasing a magnetic moment of the free layer parallel to the ABS and parallel to major planes of the layers.

Sub A1 Cont

21. A method as claimed in claim 20 wherein forming the LBS includes the steps of:

forming a hard bias layer; and

forming a nonmagnetic metal spacer layer between the free layer and the hard bias layer.

22. A method as claimed in claim 20 wherein forming the LBS further includes the steps of:

forminga ferromagnetic pinned layer;

forming a nonmagnetic metal spacer layer between the free layer and the pinned layer; and

forming an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning a magnetic moment of the pinned layer.

23. A method as claimed in claim 20 wherein the spacer layer is formed of tantalum (Ta) and the pinned layer is magnetostatically coupled to the free layer.

24. A method as claimed in claim 20 wherein the spacer layer is formed of ruthenium (Ru) and the pinned layer is antiparallel coupled to the free layer.

25. A method as claimed in claim 20 including forming the spacer layer as a nonmagnetic electrically nonconductive barrier layer.

26. A method as claimed in claim 20 further comprising:

forming the flux guide to include an extension of the free layer which extends from the sensor to the ABS;

forming the read sensor including the steps of:

forming a ferromagnetic pinned layer that has a magnetic moment;

forming an antiferromagnetic pinning layer exchange coupled to the pinned layer for pinning the magnetic moment of the pinned layer;

Sub A1 cont

forming a spacer layer between the pinned layer and said free layer; and

the forming of said pinned layer, pinning layer and spacer layer being only in said read sensor.

27. A method as claimed in claim 26 further comprising:
forming a write head including the steps of:

forming ferromagnetic first and second pole piece layers that have a yoke portion between a pole tip portion and a back gap portion;

forming a nonmagnetic write gap layer between the pole tip portions of the first and second pole piece layers;

forming an insulation stack with at least one coil layer embedded therein between the yoke portions of the first and second pole piece layers; and

connecting the first and second pole piece layers at their back gap portions.

28. A method as claimed in claim 27 including the steps of:
forming the second shield layer between the first shield layer and the second pole piece layer; and

forming the free layer between the pinned layer and the second shield layer.

29. A method as claimed in claim 27 including the steps of:
forming the second shield layer between the first shield layer and the second pole piece layer; and

forming the pinned layer between the free layer and the second shield layer.

Sub A1 cont

30. A method of making a read head that has an air bearing surface (ABS) comprising the steps of:

forming a ferromagnetic first shield layer;

forming a plurality of sensor material layers on the first shield layer;

forming a first mask on the sensor material layers recessed from the ABS for defining a stripe height of a read sensor;

milling exposed portions of the sensor material layers and back filling with a first insulation that has a thickness less than a thickness of the sensor material layers milled away;

removing the first mask;

forming a ferromagnetic free material layer on the remaining sensor material layers and the first insulation layer;

forming a longitudinal biasing stack (LBS) material layer on the free material layer;

forming a second mask on the LBS material layer recessed from the ABS for defining a track width of the read sensor and a flux guide;

milling away all exposed portions of the LBS and free material layers to form said track width and back filling with a second insulation layer;

removing the second mask;

forming a third mask on a remaining LBS material layer defining a back edge of the flux guide wherein the read head is located between the ABS and said back edge;

milling away all exposed LBS and free material layers and back filling with a third insulation layer;

removing the third mask;

forming a second shield layer on the remaining LBS and free material layers; and

lapping all remaining layers to form said ABS with the flux guide having a front edge located at the ABS.

Sub A1 cont

31. A method as claimed in claim 30 wherein the forming of the sensor material layers further includes the steps of:

forming an antiferromagnetic pinning layer on the first shield layer;

forming a ferromagnetic pinned layer exchange coupled to the pinning layer; and

forming a spacer layer on the pinned layer.

32. A method of making a read head that has an air bearing surface (ABS) comprising the steps of:

forming a ferromagnetic first shield layer;

forming a longitudinal biasing stack (LBS) on the first shield layer;

forming a plurality of sensor material layers including a ferromagnetic free layer on the first LBS;

forming a first mask on the sensor material layers for defining a stripe height of a flux guide;

milling exposed portions of the sensor material layers down to said free layer and back filling with a first insulation layer;

removing the first mask;

forming a second mask on remaining sensor material layers recessed from the ABS for defining a track width of the read sensor and the flux guide;

milling away all exposed portions of the remaining sensor material layers to form said track width and back filling with a second insulation layer;

removing the second mask;

forming a third mask on further remaining free material layers and recessed from the ABS for defining a stripe height of the read head;

milling away all exposed portions of the further remaining sensor material layers and back filling with a third insulation layer with a thickness less than the sensor material layers milled away;

removing the third mask;

Sub A1 Cond.

forming a second shield layer on still further remaining free material layers; and

lapping all still further remaining layers to form said ABS with the flux guide having a front edge located at the ABS.

33. A method as claimed in claim 32 wherein the forming of the sensor material layers further includes the steps of:

forming a spacer layer on the free layer;

forming a ferromagnetic pinned layer on the spacer layer; and

forming an antiferromagnetic pinning layer on the pinned layer.

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